Computations of Separated High-Enthalpy Hypersonic Flows: Development of RANS and Variable-Resolution PANS Approaches, Phase I

Completed Technology Project (2011 - 2011)

Project Introduction

We propose the development of a high fidelity computational approach for unsteady calculations of strongly separated non-equilibrium high-enthalpy hypersonic flows. The goal is to integrate the now proven partially-averaged Navier-Stokes (PANS) method for unsteady flow simulations with the most advanced closure models for compressibility, high-enthalpy (flow - thermodynamics coupling) and non-equilibrium (flow - chemistry coupling) effects. The PANS model has been established as a reliable model for computing separation in low and high speed regimes in two recently conclude NASA NRA projects -- 1. RANS and PANS modeling of hypersonic turbulent mixing environment; 2. Modeling of strongly separated flows with the PANS bridging method. The current proposal is to incorporate further hypersonic effect closures into PANS. Physics-based closure models for flow-thermochemistry interactions have been under development in Girimaji's group at Texas A&M under AFOSR MURI funding -- Transition and Turbulence modeling in non-thermochemical-equilibrium hypersonic flows. Important closure model building blocks for hypersonic processes are now available from the above fundamental research efforts. The combination of PANS and these advanced high-speed models will lead to a unique capability for computing hypersonic flow separation with ablation, chemistry and compressibility effects. For Phase I, we propose a logical sequence of verification-validation computations to demonstrate the potential of the various individual closures in separated high-speed high-enthalpy flows. While in-house codes are available for the proposed development, we will also consider using any of the NASA codes: USM3D, OVERFLOW, VULCAN or any of the other codes suggested by the grantor. Subsequent work (Phase II) will focus on the assembly of the individual components and development of an unique high-fidelity computational capability for hypersonic vehicle design, testing and development.

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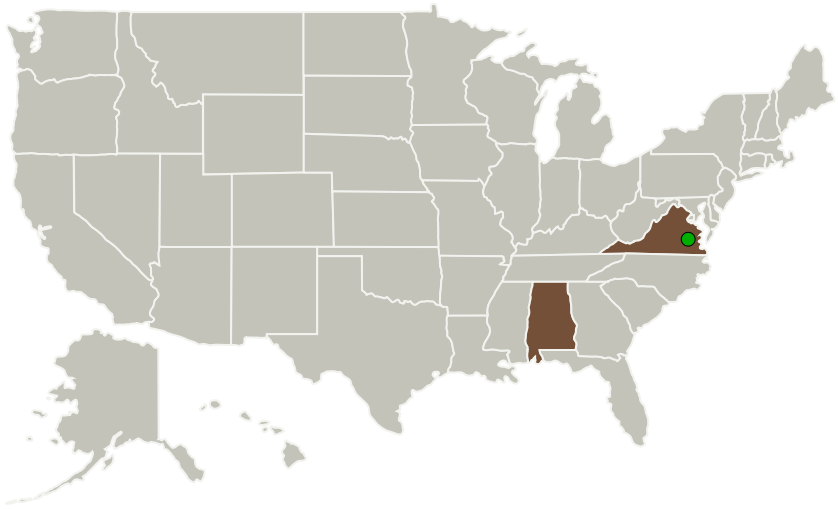
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Frendi Research Corporation	Lead Organization	Industry	Madison, Alabama
Langley Research Center(LaRC)	Supporting Organization	NASA Center	Hampton, Virginia

Primary U.S. Work Locations	
Alabama	Virginia

Project Transitions

February 2011: Project Start

September 2011: Closed out

Closeout Documentation:

- Final Summary Chart*(https://techport.nasa.gov/file/138058)*

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Frendi Research Corporation

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

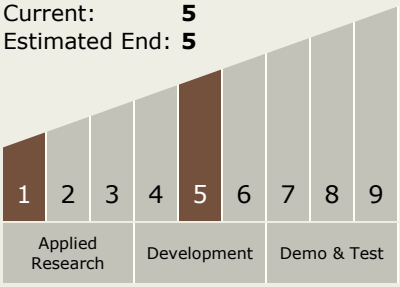
Carlos Torrez

Principal Investigator:

Kader Frendi

Technology Maturity (TRL)

Start: **1**
Current: **5**
Estimated End: **5**



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Technology Areas

Primary:

- TX09 Entry, Descent, and Landing
  - TX09.4 Vehicle Systems
    - TX09.4.5 Modeling and Simulation for EDL

Target Destinations

The Sun, Earth, The Moon, Mars, Others Inside the Solar System, Outside the Solar System